All Experimenters Meeting. March 31, 2008

Test results of the 1st Superconducting Single Spoke Cavity at FNAL for the HINS project

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on behalf of
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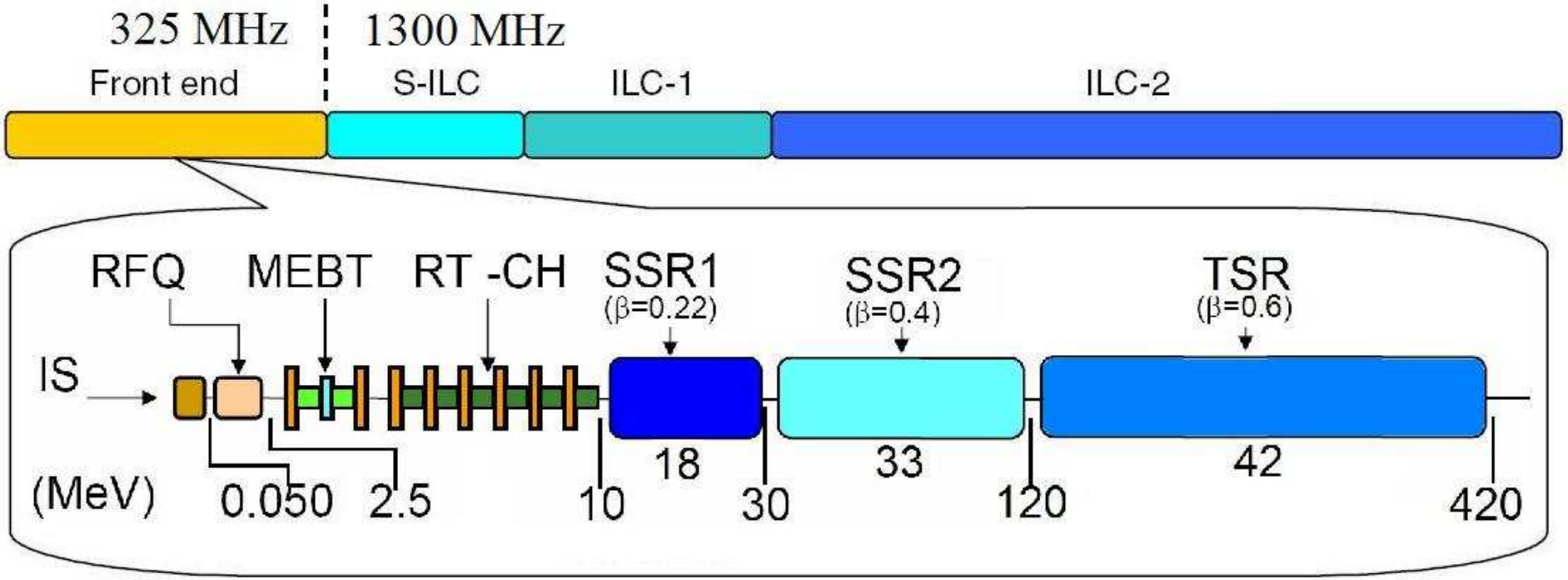
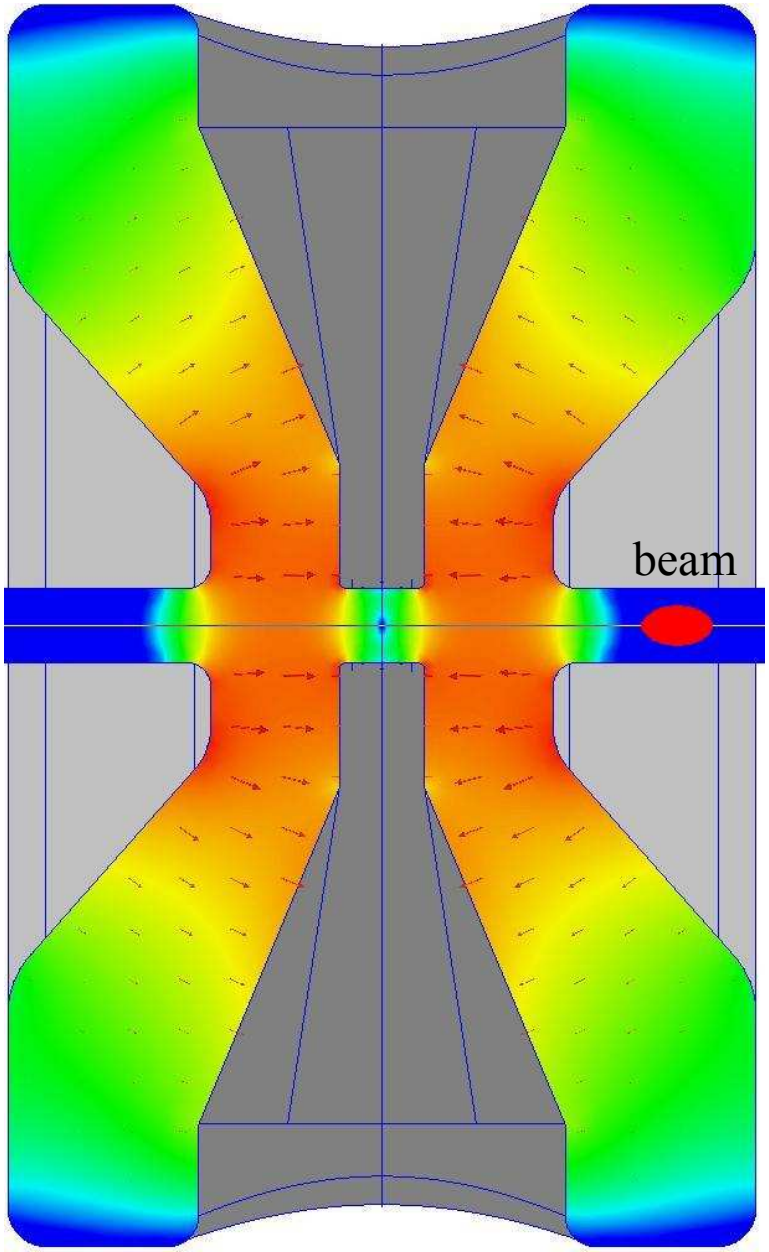
HINS Program

The front end for the Project X Linac will need several types of low β (from 0.07 up to 0.6) cavities.
The HINS R&D program is addressing this need with a novel design using superconducting cavities starting from 10 MeV.



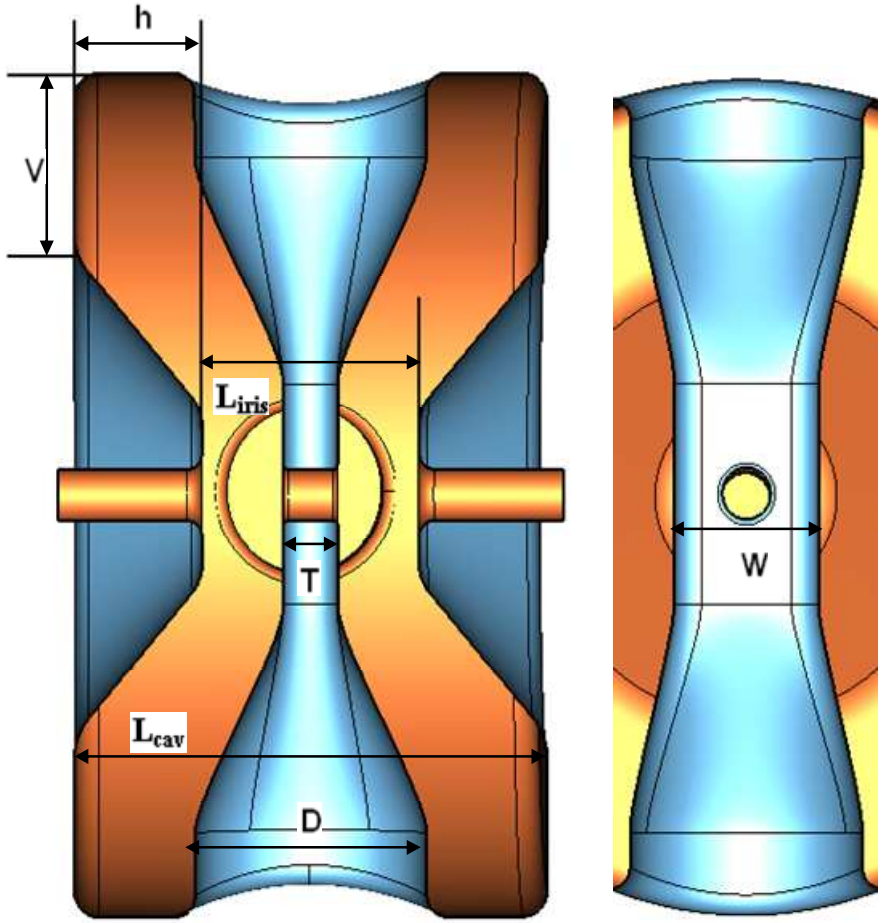
The first 18 Superconducting Single Spoke Cavities (SSR1) will accelerate beam from 10 MeV to 30 MeV. One SSR1 cavity manufactured (Zanon) and cold tested. one under production (Roark).

FNAL RF design of SSR1 (β=0.22) cavity.



Beam dynamic simulation constrains:
F = 325MHz, $R_{aperture}$ = 15mm

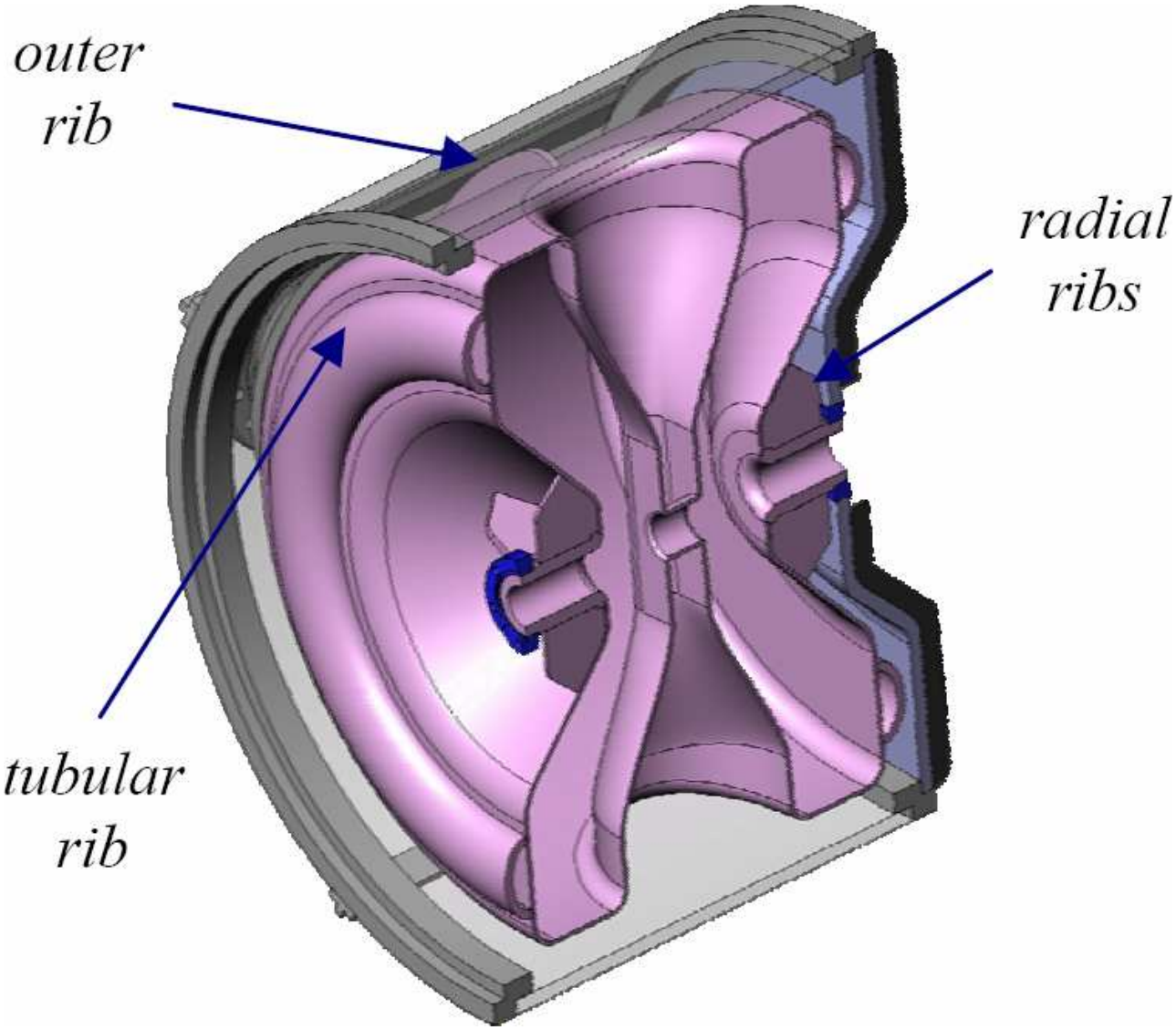
The goal of Design is minimization of E_{peak}/E_{acc} and B_{peak}/E_{acc}



FNAL Mechanical design of Cavity and Helium vessel for SSR1

The mechanical structure needs:

- to withstand the pressure exerted by the liquid helium
- providing enough stiffness to prevent the Lorentz detuning
- to have enough flexibility for cavity tuning



Fabrication and tuning of the cavity at ZANON

SSR1 in the "squirrel cage" that clamped the end walls to the outer shell

Target Operating Frequency	325.00 MHz
Vacuum to Air	-105 kHz
Vacuum Load	30 kHz
Thermal Shrinkage	-300kHz
BCP	-90kHz
Target Tuning Frequency	324.535MHz

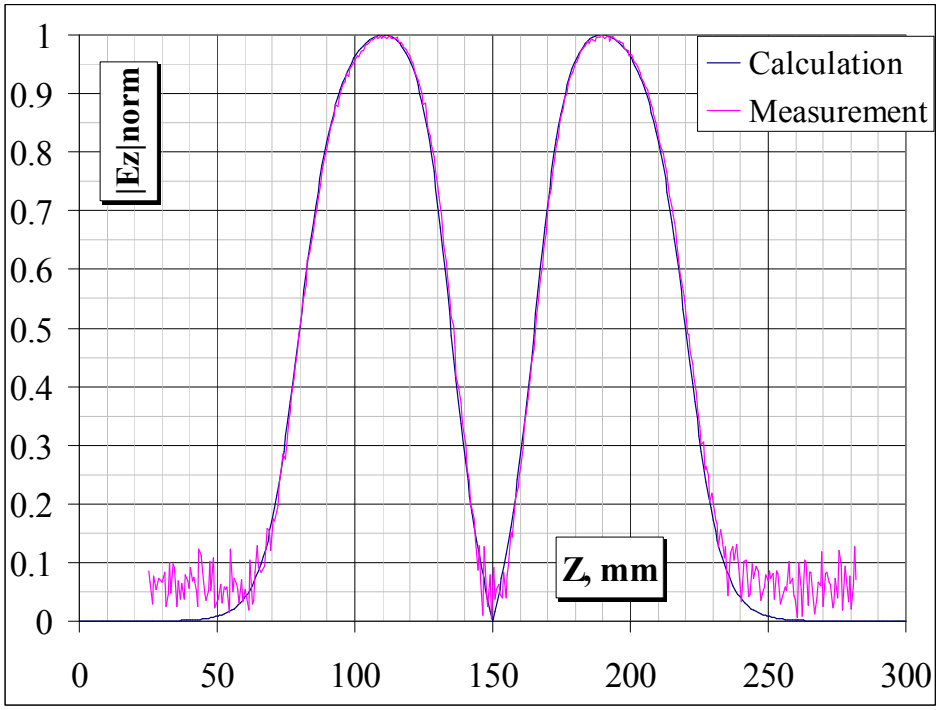
Summary of physical effects on cavity resonance frequency.

The first completed SSR1 **c**avity was tuned at ZANON with participation and inputs of FNAL scientists and engineers.

RF measurements of 1st SSR1 at FNAL

Visual and RF inspection of the arrived cavities was done in IB4.

SSR1-001 in IB4 clean room for a RF measurements.

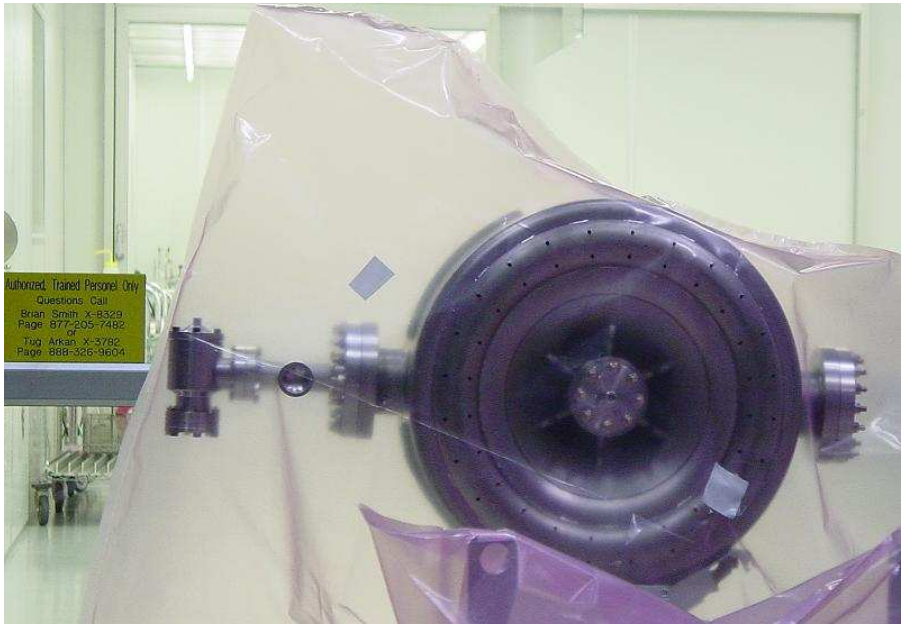


Field flatness 0.3% is very good. Operating mode frequency is F=324.76 MHz.

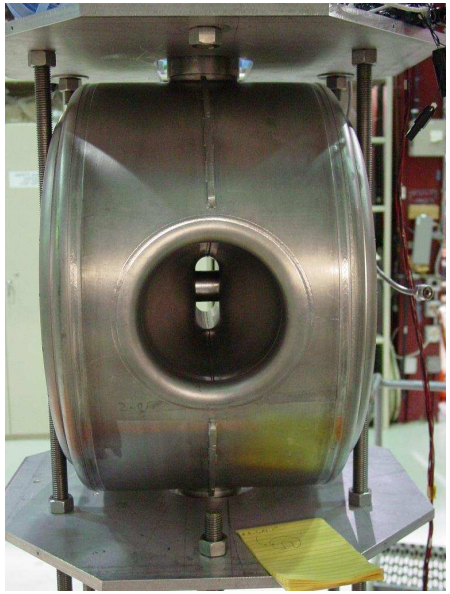
ANL/FNAL Collaboration for cavity processing

Buffered Chemical Polishing (BCP) at ANL

High Pressure water Rinsing (HPR) at ANL

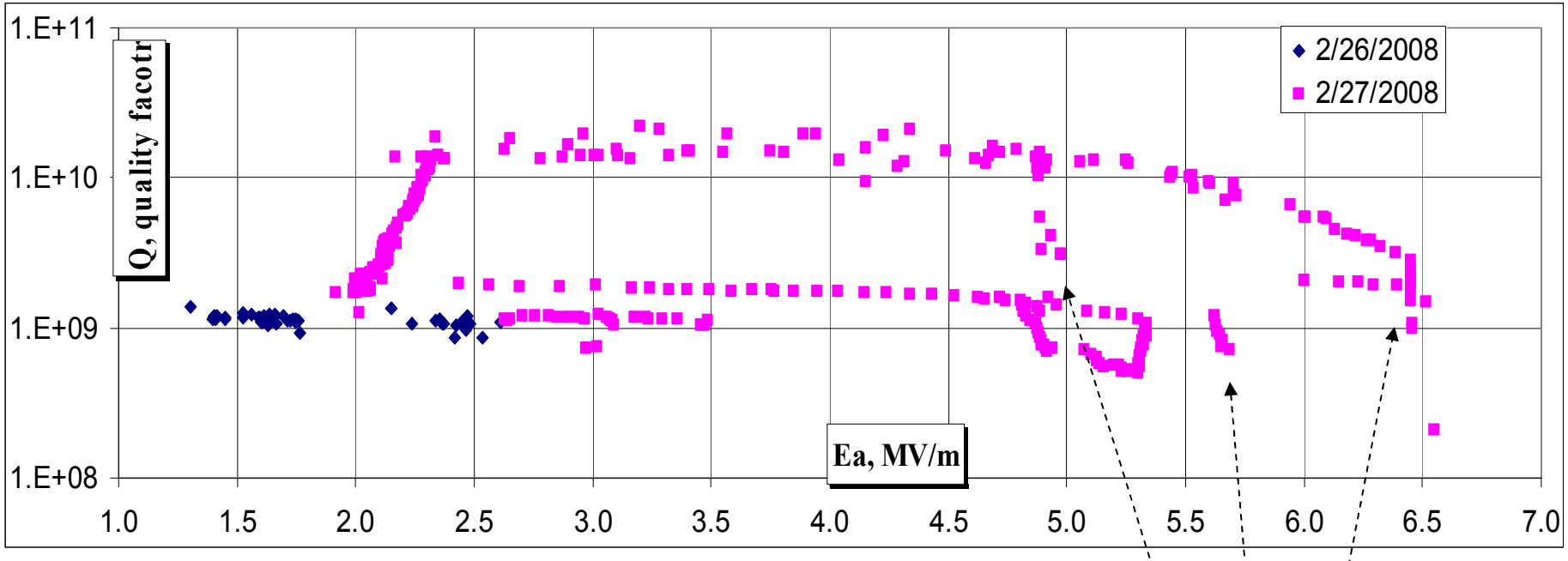


Installations of couplers, flanges and pumping line was done in MP9 class 10 clean room.

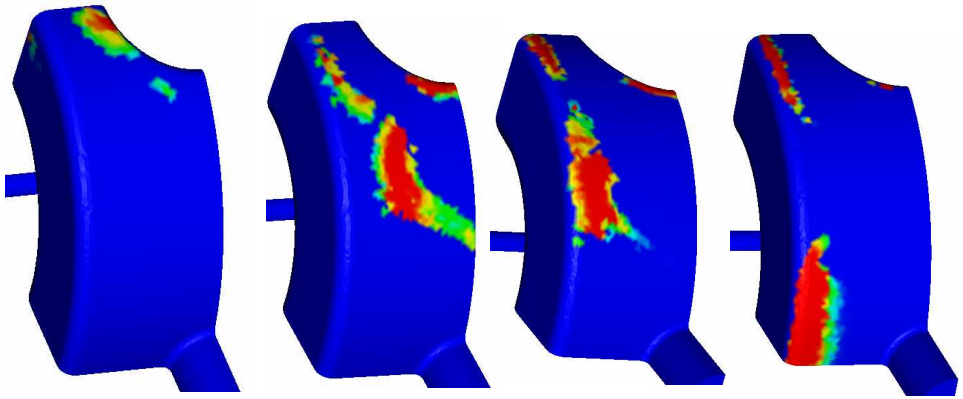


After pumping up to vacuum level 1e-8 valve was closed and cavity transported to IB1 ILC Vertical Test Station (VTS) area.

1st cold test of a 325 MHz cavity (in the World)



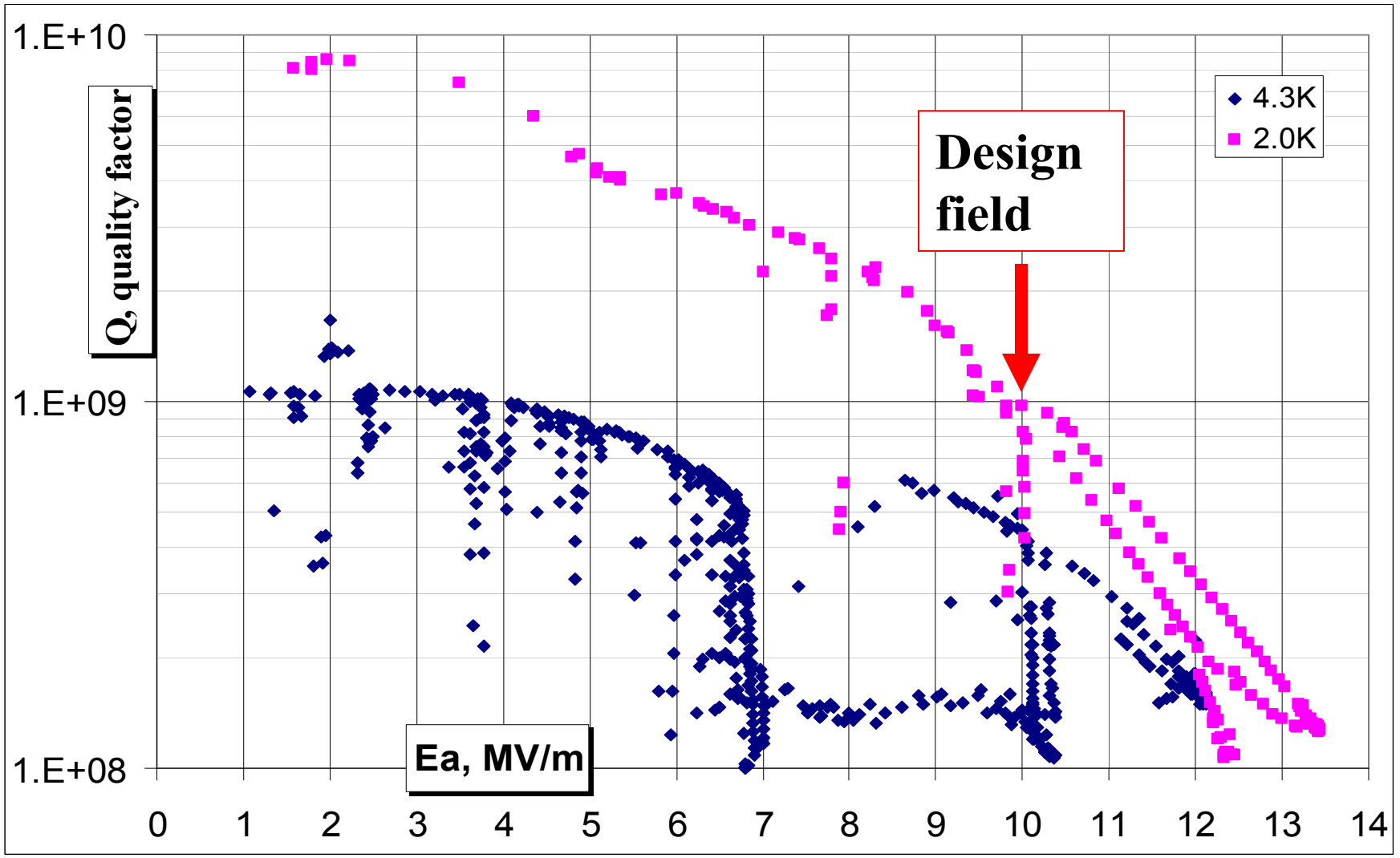
QvsE plot. Cavity quality factor at temperature T=4.3K was 1.1e9 and at T=2K 1.5e10. Residual surface resistance Rres=5 nΩ is low, in acceptable range 0-20 n Ω.



Ea~3.0 MV/m 6.5 MV/m 9.9 MV/m 14.5 MV/m

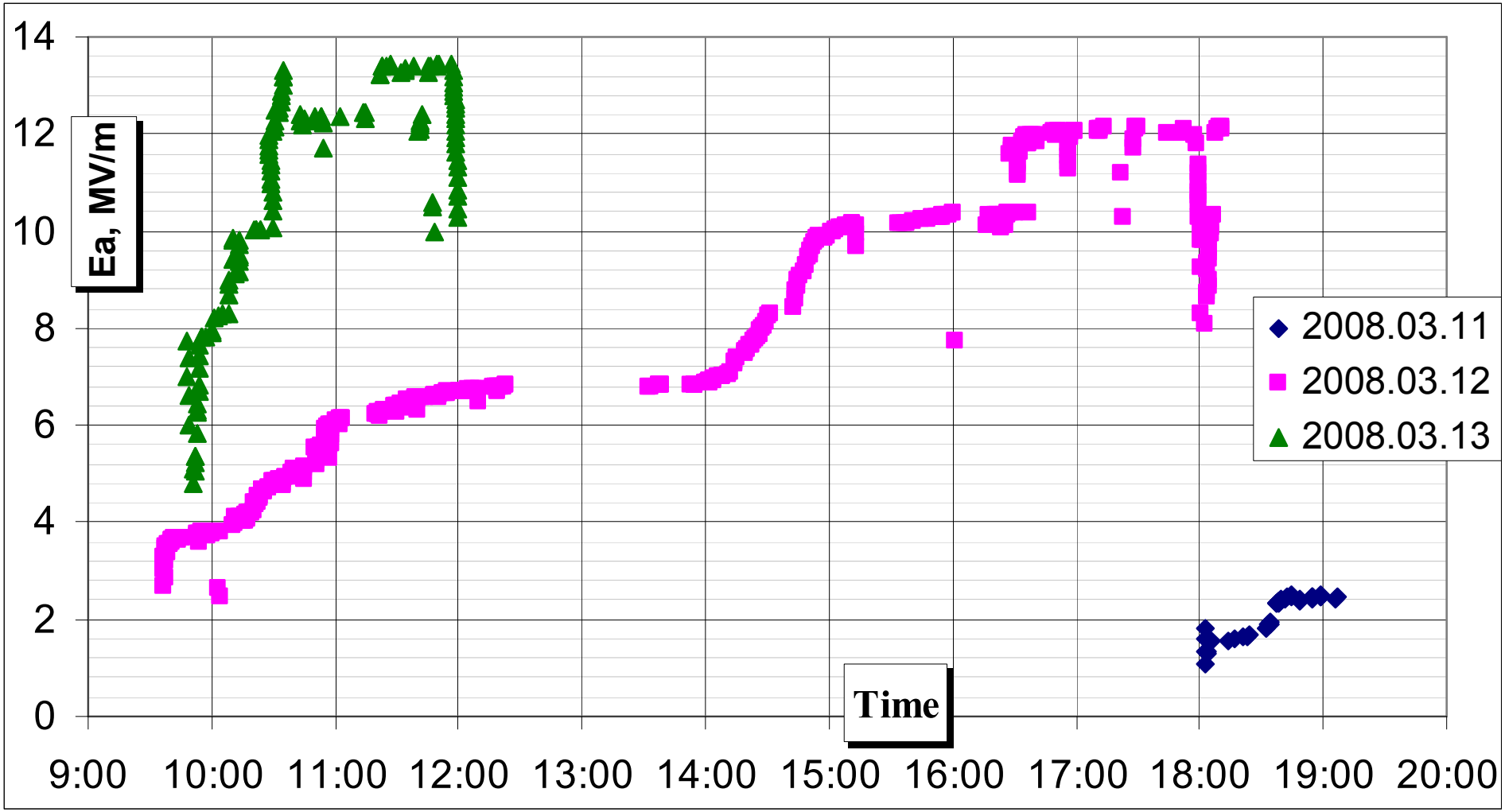
Due to complicated 3D shape of Spoke Cavity there are several multipacting areas at broad range of accelerating field. Active pumping should improve processing speed. Multipactoring calculations predicted possibility of this problem for not processed surface.

2nd cold test of a 325 MHz cavity



2008.03.13. 4 hours of work at 2K. Maximum of accelerating gradient reached 13.5MV/m limited by available amplifier power of 200 W. Operating gradient of the cavity is 10 MV/m.

Cavity Processing time



Cold test history. Processing speed improves with repetition.

Summary

1st 325 MHz SSR1 cavity has been designed, constructed, and operated at Fermilab.

Cavity achieved 135% design field.

Cavity demonstrated significant Q drop at high fields. Additional study is necessary to improve Q at operating gradient Ea=10 MV/m.

Nearest future plans of cavity study:

- 120-150C 48h bake with active pumping to reduce multipactoring, to dry cavity surface, and to heal Q-drop at high fields.

- Cold test with active pumping of the cavity volume.

- 300C bake in vacuum to diminish secondary emission coefficient and eliminate multipactoring.

- 600C bake in vacuum followed by BCP and HPR.